Cannibalization & Incentives in Venture Financing*

Stefan Arping
University of Lausanne†

Revised: May 2002

Abstract

This paper considers the effects of strategic substitutabilities on performance and incentives in venture capital financing. The analysis points to a subtle link between two pivotal roles of venture capitalists: (i) monitoring ventures and setting performance incentives, and (ii) coordinating and shaping the product market strategies of ventures operating in similar product spaces. When strategic substitutabilities are strong, the VC's role is to soften potentially too aggressive product market strategies. In contrast, small strategic substitutabilities can lead to more aggressive performance incentives. This is because they enhance the VC's commitment to weed out losers, which strengthens entrepreneurial incentives and results in overall efficiency gains. We discuss our findings in light of case study evidence from the venture capital industry.
Keywords: Venture capital, Strategic substitutabilities, Incentives
JEL–Classification: G24, G3, L1, L2, L4

*The author appreciates comments and suggestions from Michel Habib, Uli Hege, Gyöngyi Loranth, Enrico Perotti, Elu von Thadden, Masako Ueda, and Alexandre Ziegler. A preliminary version of this paper was presented at the 2001 CEPR/Gerzensee Financial Markets Symposium and benefited from the participants' comments. All errors are solely the author's responsibility.

†Address for correspondence: University of Lausanne, Ecole des HEC, BFSH1, CH–1015 Lausanne. e-mail: sarping@hec.unil.ch

Cannibalization & Incentives in Venture Financing

Executive Summary

Venture capital organizations frequently devote their funding and coaching activities to firms that operate in similar product spaces. For example, Kleiner & Perkins, a US venture capital firm, backed many of today's smaller players in the optical networking equipment sector. In fact, Kleiner & Perkins created an optical networking supply chain by investing in component makers, equipment makers (who source from the former), and final customers of optical networking gear, i.e. exchange carriers. The strategic role of synergy effects/complementarities in venture capital financing received much attention among both practitioners and the research community. Yet, interrelationships between a VC's portfolio firms are not confined to complementarities. VC organizations frequently back firms that operate in the same horizontal space, address similar needs, and fight for the same budgets. Coming back to the example of Kleiner & Perkins, within horizontal segments of the networking supply chain, firms are often best described as being actual or potential competitors. The role of strategic *substitutabilities* has received much less attention in the literature. This paper presents a framework that not only allows to address the role of strategic substitutabilities in venture capital financing and their effects on venture performance and incentives, but also to explain why VC organizations fund actual or potential competitors of already existing portfolio firms.

The analysis points to a subtle link between two pivotal roles of venture capitalists: (i) monitor portfolio firms and set strong performance incentives, and (ii) coordinate and shape the *product market strategies* of portfolio firms operating in similar product market spaces. Our findings suggest that in the presence of very strong strategic substitutabilities (two ventures being subject to intense competition in the product market), the VC's role is to *soften* the potential product market aggressiveness of portfolio firms. This superior internalization of competitive externalities creates value by avoiding excessive cannibalization and shifting rents from customers to portfolio firms. More intriguingly, however, we also show that *small* strategic substitutabilities can lead to more *aggressive* performance incentives. When a VC is invested in a competitor of a portfolio firm, he is more determined to cut down refinancing should the portfolio firm show poor performance: strategic substitutabilities help to *weed out losers* (conversely, if a venture brought strong synergies to other portfolio firms, the VC might be hesitant to cut down the venture following poor performance as he would lose the strategic benefits conveyed by

the venture). The VC's superior commitment to weed out losers strengthens the incentives of entrepreneurs to perform more aggressively. This is because when taking poor decisions and putting little entrepreneurial effort, entrepreneurs are very likely to see their ventures terminated. Entrepreneurs thus have stronger incentives to perform, which is beneficial whenever strategic substitutabilities are small (and entrepreneurs must be incentivized to perform). In case of strong substitutabilities, aggressive performance hurts other portfolio firms too much: entrepreneurial performance incentives should be softened, rather than strengthened.

We confront these findings with a detailed case study of Kleiner & Perkins' investment activities in the networking equipment space. The case study evidence suggests that Kleiner & Perkins' portfolio firms in this space are frequently best described as being actual or potential competitors. Typically, however, the ventures' respective product offerings display some degree of product differentiation. This suggests that the case of small strategic substitutabilities is most relevant. Furthermore, Kleiner & Perkins' portfolio firms are in most cases relatively successful players in their respective market segments. For example, Ciena became a leader in the market for optical switches relying on electrical regeneration of light signals through its acquisition of Lightera, a Kleiner & Perkins' portfolio firm. Ciena competes against Corvis, a Kleiner & Perkins backed maker of all–optical switches, and first mover and leader in this segment. These observations are consistent with our finding that strategic substitutabilities can lead to stronger (and thus more aggressive) performance incentives. The case study also reveals that Kleiner & Perkins frequently holds on to its portfolio investments: even long after an IPO and the expiry of IPO lock–up provisions does Kleiner & Perkins hold on to (albeit small) stakes in portfolio firms. This pattern is consistent with the idea that a VC may want to retain a stake in a portfolio firm to gain a competitive advantage in coaching and incentivizing an entrepreneur who operates in the same space and addresses similar needs as the previously funded portfolio firm.

In sum, the findings of this paper suggest that in funding situations where coaching, monitoring, and providing performance incentives matter, strategic substitutabilities help to set incentives and to improve venture performance. Venture capital organizations thus should not leave the financing of firms that may compete against their own portfolio firms to their competitors, they should finance these firms themselves. However, the effectiveness of this strategy will be limited by the extent to which venture capital organizations can commit not to opportunistically channel proprietary knowledge from one portfolio firm to another. This suggests that such practice is confined to the most reputable and established venture capital organizations.

1 Introduction

Venture capital (VC) organizations typically devote their funding and coaching activities to a small number of industries and technologies. For example, Kleiner & Perkins, a US venture capital firm, backed many of today's smaller companies in the optical networking equipment space. In fact, Kleiner & Perkins created an *optical networking supply chain* by investing in optical component makers, optical equipment makers (who source from component makers), and final customers, such as exchange carriers. This is consistent with Kleiner & Perkins' *keiretsu* approach to venture financing. The underlying idea of this approach is that building a network of ventures that *complement* each other helps to create value. Yet, a closer look at Kleiner & Perkins' networking *keiretsu* reveals that Kleiner & Perkins did not only back companies along the vertical dimension, but also *within* horizontal segments of the supply chain. This frequently involved the backing of an actual or potential competitor of a previously launched portfolio firm.[1]

Such practice is not confined to Kleiner & Perkins' investments in the networking equipment space. Industry examples suggest that VC organizations regularly finance competitors of their existing portfolio firms. For instance, Sequoia Capital backed PMC Sierra, Applied Micro Circuits, and Vitesse Semiconductor, three of the four major players in the market for communication chips.[2] Kleiner & Perkins financed E.piphany and Brio Technology, two competitors in the market for e–business analytics software.[3] Among the portfolio firms of Focus Ventures are Allegis, Agile, and SeeCommerce, three supply– and demand–chain management software makers with similar product offerings. Integral Capital Partners backed several competitors in the market for Ethernet switches and routers, such as Extreme Networks and Riverstone Networks.[4] Integral also invested in the previously mentioned software makers E.piphany, Brio Technology, and a third competitor, Informatica.[5]

These observations are puzzling. Why would a VC finance a venture that would compete against his own portfolio firms? Equivalently, why do entrepreneurs accept to be backed by investors who fund actual or potential competitors? More importantly, what are the consequences of strategic substitutabilities between a VC's

[1] Section 5 provides a detailed case study of Kleiner & Perkins' investment activities in the networking equipment space.

[2] The fourth player in the market is Broadcom.

[3] The first investments in Brio and E.piphany were made in May 1995 and January 1998, respectively, the two companies went public in May 1998 and September 1999 (see Kleiner & Perkins' website, http://www.kpcb.com). As of April and July 2000, Kleiner & Perkins had a 12% stake in E.piphany and a 6% stake in Brio (see the companies' April and July 2000 proxy filings). As for the two companies being competitors, see Brio's September 2000 10–K filing.

[4] Other Integral backed equipment makers in this space include Alantec, Whitetree, and Lantern Communications. See Lightreading at http://www.lightreading.com for a description of the competitive landscape of the Ethernet equipment market.

[5] For a list of Informatica's main competitors, see its 2000 10–K report.

portfolio firms for incentives and venture performance? In particular, would an entrepreneur's product market actions be *softened* when backed by a VC who has a stake in a venture the entrepreneur would compete with? Or are there instances when the entrepreneur would compete more *aggressively*, relative to financing by an independent VC?

This paper presents a formal framework that allows to address these questions. The framework elaborates on the financing relationship between an entrepreneur and a VC who holds a stake in a portfolio firm the entrepreneur would compete with. The VC's role is to provide funding and to *monitor* the entrepreneur's actions. Conversely, the entrepreneur's contribution is to work hard, i.e. to provide effort. By expending effort, the entrepreneur ensures that her venture will be successful. At the same time, however, she will exert a negative externality on the previously launched portfolio firm. The novel contribution of this paper is to highlight how the strategic substitutabability between the two ventures channels into the entrepreneur's incentives to perform by altering the VC's *incentives* and *ability* to provide tough or soft entrepreneurial incentive schemes.

We show that, in some cases, the VC will finance the venture in order to prevent the entrepreneur from seeking finance elsewhere and to *soften* her product market aggressiveness. This enables the VC to control the entrepreneur and to *align* her incentives with his own interests. In many other cases, however, the VC will rationally back the venture even though the entrepreneur would have been less aggressive if financed by an independent VC. In other words, the VC willingly *cannibalizes* his own portfolio firm. The intuition is that the VC's stake in the previously launched venture gives him a *competitive advantage* in incentivizing an actual or potential competitor of the venture. This is because the stake in the incumbent venture conveys the VC with superior commitment to cut down refinancing should the entrepreneur perform poorly. In contrast, under independent VC financing, a threat to cut down refinancing may lack credibility as an independent VC has *too much to lose* and *too little to gain* from terminating the venture. A stake in a competing venture allows to *restore* the credibility of a termination threat and hence to commit the entrepreneur to work harder. At the same time, however, the VC would not have excessive incentives to cut down the venture in order to protect his previously launched portfolio firm. This is because the VC not only has something to gain from terminating the venture, but also something to lose, namely his financial claim in the venture. In other words, a stake in a competing firm gives an additional degree of freedom which allows to *optimize* the balance between excessive and too soft incentives to cut down refinancing.

Results depend critically on the strength of the negative externality the entrepreneur imposes on the VC's portfolio firm. When the strategic substitutability between the two ventures is very small, then there is neither a reason to soften the entrepreneur's product market actions (her effort level) nor a means to make her work harder. This is because the *jointly* efficient effort level is still above the distorted effort level under independent VC financing, but termination threats are

not yet effective. If the negative externality imposed on the VC's portfolio firm is neither too small nor too large, the entrepreneur will be more aggressive than under independent VC financing. In this case, the VC holds a *tough* claim in the venture. In particular, the VC is equipped with strong termination rights. If the negative externality becomes larger, the VC will take a *soft* equity–like claim in the venture, essentially, in order to prevent the entrepreneur from working *too* hard (which would severely undermine the competitive stance of the VC's portfolio firm).

The analysis thus points to several novel implications: (i) Seeking funding from a VC who is invested in an actual or potential competitor can be *value–enhancing* for an entrepreneur. Similarly, a VC may have strong incentives to back a venture that operates in the same space, addresses similar needs, and may even become a competitor of an existing portfolio firm; (ii) relative to independent VC financing, the entrepreneur may act more aggressively if backed by the competitor–affiliated VC. This is because the VC's stake in the competitor enhances his ability to incentivize the entrepreneur; (iii) the VC may want to retain a stake in a portfolio firm, even after the firm's IPO, in order to enhance his *competitive advantage* in financing related, potentially competing ventures.

We confront the analysis with a case study of the investment activities of Kleiner & Perkins in the networking equipment space. The case study suggests that (i) Kleiner & Perkins indeed backed actual or potential competitors of previously funded portfolio firms, while still being invested in these firms; (ii) Kleiner & Perkins played no role in *softening* competition. To the contrary, some of its ventures became fierce competitors. At the same time, however, the ventures seem to be relatively successful players in their respective market segments. This is consistent with our central finding that strategic substitutabilities between a VC's portfolio firms enable the VC to strengthen performance incentives; (iii) Kleiner & Perkins frequently continued to be invested in its portfolio firms, even long after a portfolio firm's IPO. This is consistent with systematic empirical evidence indicating that VC organizations often retain substantial holdings in their portfolio firms, even after the expiry of lock–up provisions (Barry et al. 1990, Gompers and Lerner 1999, Megginson and Weiss 1991). Our analysis provides a novel explanation for this pattern.

The present research adds to several strands of the literature. Hellmann (2002) investigates how strategic externalities affect a VC's *coaching incentives*. He finds that strong complementarities between a venture and the VC's investment portfolio commit the VC to support the venture. In case of negative externalities/substitutabilities (e.g. because the VC is invested in a product market competitor), the venture will be financed by an *independent* investor. Hellmann (2002) also shows that if the negative externality becomes larger, the VC may take a passive equity stake in the venture in order to *weaken* the independent investor's incentives to provide too much support. While Hellmann (2002) emphasizes the dark side of substitutabilities, we point to their *beneficial* aspects, stemming from the VC's improved ability to incentivize the entrepreneur. Building on earlier work by Bhattacharya and Chiesa (1995), Leshchinskii (2000) points to a VC's *coordination role*

when funding and coaching two related ventures. He shows that joint funding is beneficial in order to coordinate R&D investment and, in case of competing ventures, to soften competition by monopolizing one venture and terminating the other. There is also a relatively large industrial organization literature on the competitive effects of collaborations between competitors (see e.g. Grossman and Shapiro 1986, Ordover and Willig 1985, and Shapiro and Willig 1990 for an overview and further references). In this literature, pro–competitive effects stem from cost efficiencies (resource sharing, joint R&D etc.), while anti–competitive effects arise from the internalization of competitive externalities.

These contributions largely suggest that a venture's product market actions and performance should be *softened* when financed by a VC who holds a stake in an actual or potential competitor, stemming from the previously mentioned internalization of competitive externalities. Similarly, the VC may want to induce exit of the entrepreneur, as he partially internalizes the positive externality termination of the entrepreneur's venture would exert on the previously funded competitor. The intuition behind this paper's findings stems from the observation that, in the presence of agency problems, it might well be jointly efficient for the VC and the entrepreneur to commit the entrepreneur to better performance, even if this comes at the expense of the portfolio firm. Yet, the VC's stake in the portfolio firm enhances the credibility of a threat to respond to poor performance with termination. This enables the VC to incentivize the entrepreneur to perform more aggressively than under independent VC financing. We draw on a similar observation in a companion paper that explores the antitrust effects of bank–commerce affiliations (Arping 2001). There we consider the effects of a bank's equity stake in an established competitor of a borrower on the bank's ability to commit the borrower not to default strategically (or to divert funds). We show that the bank's stake in the competitor relaxes the borrower's financing constraints. The present paper shows that a similar insight can be used to not only explain why VC organizations finance ventures that compete against their own portfolio firms, but also to demonstrate that such practice can strengthen entrepreneurial incentives to compete more aggressively.

The paper is organized as follows. Section 2 outlines the formal framework. Section 3 derives optimal contracts and equilibrium outcomes under independent VC financing. Section 4 turns to venturing by the competitor–affiliated VC and presents the main results of the paper. Section 5 confronts the analysis with a case study of Kleiner & Perkins' investment activities in the networking equipment space. Section 6 concludes. Proofs are relegated to the appendix.

2 Model

2.1 Informal Overview

The framework is designed to capture in the most simple fashion critical features of the interaction between an entrepreneur and a venture capitalist (VC), who pre-

viously funded a venture the entrepreneur would compete with. The VC's role is to provide funding and to *monitor* the entrepreneur's actions. By expending effort, the entrepreneur increases the success prospects of her venture. At the same time, however, she will exert a negative externality on the previously launched portfolio firm of the VC. We will analyze how the strength of the strategic substitutability between the two ventures affects (i) the VC's incentives and ability to provide tough or soft entrepreneurial incentive schemes; and (ii) the entrepreneur's incentives to perform (and, hence, her product market aggressiveness).

2.2 Agents and Timing

An entrepreneur needs outside funding to finance a venture. Funding is to be provided by a venture capitalist (VC). There is a *strategic* VC and there are *independent* VCs. The strategic VC differs from an independent VC in that the entrepreneur would exert a *negative externality* on his existing investment portfolio through competing against one of his portfolio firms. In contrast, independent VCs' investment portfolios are *unrelated* to the venture. All agents are risk–neutral and the risk free interest rate is normalized to zero. There are four dates, $t = 0, 1, 2, 3$. The timing of events is summarized in figure 1.

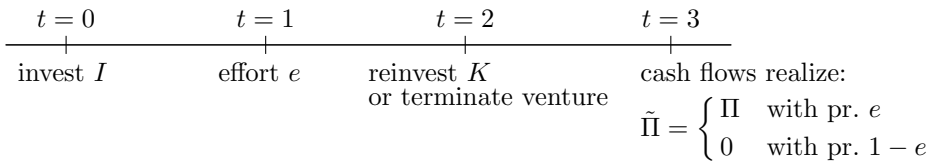

Figure 1: Timing

At $t = 0$, there is a fixed start–up investment $I > 0$. At a later stage, at $t = 2$, the project requires a second (fixed) cash infusion $K > 0$ in order to continue until final cash flows realize at $t = 3$. The entrepreneur has own wealth $A < I$, i.e. is neither able to self–finance the initial investment outlay I, nor the reinvestment K. At $t = 1$, the entrepreneur expends privately costly and unverifiable effort $e \in [0, 1]$ (examples time and effort devoted to R&D, finding out what potential customers want, cutting prices and committing to additional orders from customers etc.). The effort cost function $\psi(e)$ is three times continuously differentiable, strictly increasing and convex, and satisfies the following standard regularity conditions: $\psi(0) = \psi'(0) = 0$, $\psi'''(e) \geq 0$, and $\lim_{e \to 1} \psi'(e) = \infty$. The more effort the entrepreneur exerts at this stage, the larger will be the likelihood that her product ultimately succeeds in the market place. However, neither the entrepreneur nor an investor know with certainty whether the project succeeds until final cash flows realize at $t = 3$. That is, the ultimate test whether the product succeeds or not is to be provided by the mar-

ket place. The entrepreneur is *indispensable* for running the venture and deploying her product idea.[6]

Provided the venture receives the reinvestment K, final and verifiable cash flows realize at $t = 3$. Given effort $e \in [0, 1]$, the project is successful with probability e and fails with probability $1 - e$. For simplicity, cash flows are zero in case of failure. In case of success, cash flows are given by $\Pi > 0$. If the reinvestment is not expended at $t = 2$, the venture has to close down and is terminated. In order to sharpen the analysis, we will assume that assets have zero liquidation value. This seems to be most relevant for the case of venture capital financing, where start–up firms' assets typically provide very little collateral value.

2.3 Funding Sources: Strategic vs Independent Venturing

As was mentioned earlier, the entrepreneur has two potential funding sources: she can either approach one of many *independent* VCs or she can approach the *strategic* VC. Crucially, the entrepreneur would exert a *negative externality* on the strategic VC's investment portfolio through undermining the competitive stance of a portfolio firm the strategic VC is invested in.[7] This is modelled in the most simple and straightforward fashion by adopting a reduced from approach:[8] if the entrepreneur stays out or is liquidated at $t = 2$, the strategic VC gets V at $t = 3$. If the entrepreneur enters and is not liquidated, then no matter whether the entrepreneur is financed by the strategic VC or by an independent VC, the strategic VC's existing investment portfolio generates income $V - \Delta$ if the entrepreneur is successful and V if the entrepreneur fails, where $\Delta > 0$. The parameter Δ should be interpreted as the *intensity* of competition or as the *strength* of the strategic substitutability between the two ventures.[9] When Δ is very small, the ventures' product offerings are almost

[6]The implications of this assumption are two fold: First, the venture cannot be continued if the entrepreneur is fired and replaced by another entrepreneur (for example, an entrepreneur with deep pockets). Second, investors cannot "steal" the entrepreneur's product idea. This latter issue may be of concern in our context. We discuss in section 4 how to extend the framework along those lines.

[7]Throughout the paper, we will be relatively mute about the portfolio firm (e.g. its actions). See section 4 and the conclusions for further discussion.

[8]One could refer to a standard Hotelling type of framework (see e.g. Tirole 1990) in order to explicitly model the product market interaction between the two ventures. However, such an explicit treatment is not needed for our purposes. It would only put a burden on clarity of the exposition.

[9]Two companies A and B compete if A's aggressive pricing constrains B's ability to charge high price–cost margins (see e.g. Porter 1985 and Tirole 1990). This does not preclude the possibility that the companies' product offerings are highly differentiated. In case of highly differentiated products, A will exert a small negative externality on B (et vice versa), while in case of less differentiated products the negative externality will be larger. This feature is captured by our framework and plays an important role in the analysis. A and B are *potential* competitors if B's ability to charge high margins is constrained by A's ability to mimick B's product. For example, if B's high margins signaled A that money is to be made from mimicking B's product, B might refrain from charging too high prices (while B would charge higher prices if A were not around). For the analysis, it is relatively unimportant whether the two ventures are actual or potential competitors. What is important is that the previously funded portfolio firm benefits from the entrepreneur's venture being terminated.

unrelated; when Δ is large, there is a substantial degree of substitutability between the two ventures.[10]

The parameter assumptions ($\Delta > 0$) imply that *if* the entrepreneur were backed by an independent VC and the strategic VC had no financial claim in the venture, then from the strategic VC's perspective the entrepreneur should be liquidated at $t = 2$ (or not enter at all). Similarly, if the entrepreneur stayed around until $t = 3$, then, at least, she should refrain from working. In other words, if the strategic VC financed the entrepreneur's venture and did not prevent the entrepreneur from working (or even induced her to work harder than under independent venturing), he would *cannibalize* his existing investment portfolio. The strategic VC may, however, soften (or, in principle, strengthen) the entrepreneur's aggressiveness by *altering her incentives*. The strategic VC may, in principle, also prevent the entrepreneur from competing altogether by acquiring and shelving her product idea (and having the entrepreneur sign a non–compete clause).[11]

2.4 Monitoring

Apart from providing funding, a key role of the VC (be it the strategic VC or an independent VC) is to *monitor* the entrepreneur.[12] This involves visiting the venture on a regular basis and inspecting the entrepreneur's progress in developing her venture. As a result of these monitoring activities (whose costs are ignored, for simplicity), an investor who starts a financing relationship with the entrepreneur at $t = 0$ is able to observe the entrepreneur's effort choice. We assume, however, that effort is unverifiable, i.e. unobservable by the courts. This precludes conditioning financial contracts on effort. Monitoring thus refers to the *gathering* of *soft* information (rather than gathering hard information or interfering with entrepreneurial decision making).

In our framework, monitoring and staged financing are beneficial because they enable the VC to condition refinancing on the entrepreneur's performance. In particular, provided the VC is not obliged (by a contract) to provide refinancing, the entrepreneur may have superior incentives to work hard in order to induce the VC to provide refinancing at better terms. To allow for this possibility, we will equip the VC with the *option* to withhold refinancing.[13] If after having observed the entrepreneur's effort the VC happens to be better off with withholding refinancing

[10] The parameter Δ is also influenced by the size and the cash flow sensitivity of the VC's claim in the portfolio firm.

[11] Non–compete clauses are commonplace in venture financing (Kaplan and Strömberg 2001). However, in some jurisdictions (e.g. the State of California) non–compete clauses are not enforceable. We discuss below how the analysis would be altered if non–compete clauses could not be enforced in court.

[12] See Gompers (1995), Gorman and Sahlman (1989), Hellmann and Puri (2000), Lerner (1995), and Sahlman (1990) for empirical evidence pointing to the pivotal role of VCs in monitoring their portfolio firms.

[13] This will be optimal in our framework. It is also consistent with empirical evidence put forward by Gompers (1995), Kaplan and Strömberg (2000), and Sahlman (1990) that investment and financing are typically staged and that termination rights held by VCs are pretty draconian.

but reinvestment is efficient, then the entrepreneur has the opportunity to make a new offer that makes the VC willing to close the refinancing gap (in other words, the entrepreneur would have to raise the VC's compensation). We assume that the entrepreneur has the bargaining power when making such an offer.[14] Furthermore, renegotiation is bilateral, i.e. only the initial investor and the entrepreneur bargain over contract terms. Uninformed outsiders stay out.

We exclude side contracting between an independent VC and the strategic VC or between the entrepreneur and the strategic VC under independent venture financing. Specifically, at $t = 0$, the entrepreneur will bargain with either the strategic VC or an independent VC about funding terms. If she obtains funding from either party, she won't see the other again. Lastly, the entrepreneur has the ex ante bargaining power over investors (including the strategic VC).[15]

3 Independent VC Financing

This section considers the financing problem between the entrepreneur and an independent VC. A financial contract specifies the VC's share α of the venture's cash flows, conditional on the VC contributing $I - A$ at $t = 0$ and providing refinancing K at $t = 2$.[16] To see how the VC's option to withhold refinancing can discipline the entrepreneur note that if the VC provides refinancing immediately (without further bargaining with the entrepreneur) he derives an expected payoff of $e\alpha\Pi - K$, where e is the *actual* effort level expended by the entrepreneur. If the VC does not provide refinancing, his payoff is zero. Hence, the VC is willing to provide refinancing immediately if and only if $e\alpha\Pi \geq K$, i.e. the entrepreneur works hard enough. Conversely, for $e\alpha\Pi < K$, the VC does not provide refinancing immediately. Instead, the VC lets the entrepreneur make him a better offer. The entrepreneur thus partially internalizes the cost of shirking. In what follows, we elaborate on this renegotiation game between the VC and the entrepreneur.

Suppose first that refinancing the venture is inefficient, given the entrepreneur's effort level, $e < K/\Pi$. Thus, even if the entrepreneur were to offer the VC a 100% stake in her venture in exchange for the VC providing funding, the VC would not break even. Consequently, the VC decides to terminate the venture. Next, suppose that $K/\Pi \leq e < K/(\alpha\Pi)$, so the VC is still better off with withholding refinancing. However, reinvestment is efficient and expected cash flows are sufficient

[14] Crucially, the entrepreneur has to have some bargaining power in renegotiation. If the investor had the full bargaining power, the investor would abuse his power to withhold refinancing even if the entrepreneur did not shirk (Rajan 1992). Consequently, the investor would have to commit ex ante to provide full refinancing and monitoring would be pointless. As for the case of venture financing, one could argue that the hold up problem presumably is of little concern as VCs would lose their reputational capital if engaging in such practice. If the hold up problem were a serious concern, then one should not observe VCs holding draconian termination rights.

[15] This is purely for simplicity. If the strategic VC had the ex ante bargaining power over the entrepreneur, the paper's results would be strengthened.

[16] It is easily verified that under independent VC financing the entrepreneur invests her entire wealth into the project in order to minimize the outside financing burden.

to compensate the VC for providing K. The entrepreneur thus offers a larger share, $\alpha(e) > \alpha$, in order to induce the VC to provide refinancing. The VC is willing to accept the entrepreneur's offer if and only if $e\alpha(e)\Pi \geq K$. After renegotiation, the VC thus holds a stake $\alpha(e) = K/(e\Pi) > \alpha$. Finally, for $e \geq K/(\alpha\Pi)$, the VC is better off providing refinancing immediately. The entrepreneur's payoff function (before taking effort) thus amounts to

$$U(e) = \begin{cases} -\psi(e) & \text{for } e < \frac{K}{\Pi} \\ e\Pi - K - \psi(e) & \text{for } e \in \left[\frac{K}{\Pi}, \frac{K}{\alpha\Pi}\right) \\ e(1-\alpha)\Pi - \psi(e) & \text{for } e \geq \frac{K}{\alpha\Pi} \end{cases} \tag{1}$$

Let e^{**} denote the entrepreneur's *equilibrium* effort level under independent VC financing. For the VC to break even, $e^{**}\alpha\Pi = I - A + K$, or $\alpha = (I - A + K)/(e^{**}\Pi)$. Note then that

$$e^{**} > \frac{K}{\alpha\Pi} = \frac{e^{**}K}{I - A + K} \tag{2}$$

since $I > A$. In other words, a threat to terminate the venture following a slight deviation from the equilibrium effort level *lacks credibility*. The equilibrium effort level is thus characterized by the standard incentive constraint under *arm's length financing*,

$$(1 - \alpha)\Pi = \psi'(e^{**}) \tag{3}$$

The *first best* effort level under independent VC financing is turn given by the (unique and interior) solution of $\Pi = \psi'(e^{FB})$. We can claim the following

Proposition 1 *Under independent VC financing, the VC provides initial funding $I - A$ and refinancing K and obtains a share $\alpha = (I - A + K)/(e^{**}\Pi)$ of the venture's cash flows. The entrepreneur's performance e^{**} is given by the largest solution of*

$$\left(1 - \frac{I - A + K}{e^{**}\Pi}\right)\Pi = \psi'(e^{**}) \tag{4}$$

Performance is strictly inferior to the first best effort level e^{FB}. ■

A threat to withhold refinancing provides no disciplinary power under independent VC financing. Hence, it does not allow to improve performance upon arm's length financing. The intuition is that following a slight deviation from the equilibrium effort level the VC has *too much to lose* and *too little to gain* from terminating the venture. The VC would lose his long term financial claim in the venture. In equilibrium, this claim is just sufficient to compensate the VC for the initial investment $I - A > 0$ *and* the refinancing funds K. What the VC gains from not refinancing is the reinvestment K. Hence, as long as $I > A$, the VC would not use the termination option as a threat point in renegotiation, following a small deviation from the equilibrium effort level.[17] Instead, he would pick the refinancing option. A threat

[17] This mirrors results by Repullo and Suarez (1998), who examine the effects of collateral and multiple source financing on the credibility of liquidation threats and managerial incentives. They show that strong collateral values enhance managerial incentives to perform. As will be shown below, our analysis suggests that a stake in a competitor can effectively serve as a substitute for collateral. This seems to be particularly relevant in venture capital financing, where assets typically have little collateral value.

to terminate thus lacks credibility, implying that the only sustainable effort level is the equilibrium effort level under arm's length financing.

We assume that independent VC financing is feasible and profitable, implying that the joint surplus gain for the independent VC and the entrepreneur is strictly positive,

$$e^{**}\Pi - \psi(e^{**}) - I - K > 0 \tag{5}$$

Furthermore, *in equilibrium*, reinvestment must be ex post efficient. Otherwise, outside financing would not have been feasible in the first place. The entrepreneur's payoff under independent VC financing thus amounts to

$$e^{**}\Pi - \psi(e^{**}) - I + A - K > A \tag{6}$$

while the *strategic* VC derives a payoff of

$$e^{**}(V - \Delta) + (1 - e^{**})V < V \tag{7}$$

The payoffs under independent VC financing define the parties' respective *outside option payoffs* under venturing by the strategic VC.

4 Cannibalization & Incentives

We now turn to venturing by the strategic VC, taking the parties' outside option payoffs as given. Let e^* denote the entrepreneur's equilibrium effort level under venturing by the strategic VC. Conditional on the venture being refinanced, the ex ante *joint* surplus of the VC and the entrepreneur from launching the venture amounts to

$$e^*(\Pi + V - \Delta) + (1 - e^*)V - I - K - \psi(e^*) \tag{8}$$

Conversely, if the venture is not launched, the joint surplus is given by V. Launching the venture is thus *jointly efficient* for the entrepreneur and the VC if and only if

$$e^*(\Pi - \Delta) - I - K - \psi(e^*) \geq 0 \tag{9}$$

which holds for e^* sufficiently large and Δ sufficiently small. Denote by $e^{FB}(\Delta)$ the *jointly* efficient effort level for the entrepreneur and the VC, conditional on the venture being launched and refinanced. By inspection, for $\Pi \geq \Delta$, the jointly efficient effort level is given by the solution of

$$\Pi - \Delta - \psi'(e) = 0 \tag{10}$$

Note that $e^{FB}(\Delta)$ is continuous and strictly decreasing in Δ. In other words, the jointly efficient effort level under venturing by the strategic VC is strictly inferior to the *first best* effort level under independent VC financing. This stems of course from the negative externality the entrepreneur exerts on the strategic investor's portfolio firm when working hard.

Suppose the entrepreneur would stick to the first best effort level if the venture were launched. Hence, launching the venture would be efficient if and only if

$$\mathcal{S}(\Delta) = e^{FB}(\Delta)(\Pi - \Delta) - K - I - \psi(e^{FB}(\Delta)) \geq 0 \tag{11}$$

Note that $\mathcal{S}(\Delta)$ is continuous and strictly decreasing,[18] and satisfies $\mathcal{S}(0) > 0$ and $\mathcal{S}(\Pi) < 0$. Hence, there exists a critical threshold $\Delta^* \in (0, \Pi)$ such that launching the venture would be efficient if and only if $\Delta \leq \Delta^*$, provided the entrepreneur sticked to the first best effort level. Summarizing,

Lemma 1 *Suppose the entrepreneur is financed by the strategic VC. Then, there exists a threshold $\Delta^* \in (0, \Pi)$ such that for $\Delta \leq \Delta^*$ the venture is launched under the first best. The entrepreneur's effort level under the first best is strictly decreasing in Δ. For $\Delta > \Delta^*$, the venture is not launched and the entrepreneur's product market idea is shelved.* ■

The lemma shows that in the absence of moral hazard the entrepreneur's performance under venturing by the strategic VC would be strictly inferior to her performance under independent VC financing. Furthermore, as the negative externality imposed on the strategic VC becomes stronger, the entrepreneur would compete less aggressively. While these observations provide a useful benchmark, they might be irrelevant in practice. In particular, as long as Δ is not too large, the jointly efficient effort level will exceed the distorted effort level under independent VC financing. In this case, it will be jointly efficient for the entrepreneur and the strategic VC to compete more aggressively than under independent venturing, even though this undermines the competitive stance of the strategic VC's portfolio firm. Formally, define $\bar{\Delta}$ by

$$e^{FB}(\bar{\Delta}) \equiv e^{**} \tag{12}$$

From the first order condition defining the first best effort level, (10), and the incentive constraint under arm's length financing (4), $\bar{\Delta}$ is given by

$$\bar{\Delta} = \frac{I - A + K}{e^{**}} \tag{13}$$

For $\Delta < \bar{\Delta}$, the *jointly* efficient effort level for the entrepreneur and the VC strictly exceeds the equilibrium effort level under independent venturing. Next, define $\underline{\Delta}$ by

$$e^{**}\underline{\Delta} \equiv I - A \tag{14}$$

Note that $0 < \underline{\Delta} < \bar{\Delta} < \Pi$. The following lemma shows that $\Delta \geq \underline{\Delta}$ is a necessary condition for the entrepreneur's performance to be higher than under independent venturing.

Lemma 2 *Suppose the entrepreneur is financed by the strategic VC and the venture is launched. Then, as long as the strategic VC breaks even in equilibrium, a threat to terminate the venture following a slight deviation from the equilibrium effort level is credible if and only if $\Delta \geq \underline{\Delta}$.* ■

[18] Formally, from the envelope theorem, $\mathcal{S}'(\Delta) = -e^{FB}(\Delta) < 0$ (for $\Delta < \Pi$).

Intuitively, as long as $e^{**}\Delta \geq I-A$, the potential gain from financing the venture and exercising the termination option is more than sufficient to compensate the strategic VC for providing $I-A$, even if the entrepreneur does not promise any payment prior to the VC providing refinancing. This is because if the strategic VC did not finance the venture, he would derive a payoff of $V - e^{**}\Delta$. If he financed the venture and exercised the termination option, his payoff would amount to $V - (I - A)$. Hence, as long as $e^{**}\Delta \geq I - A$, there is in principle no need to promise the strategic VC a stake in the venture in order for the VC to be willing to provide the initial financing. This implies that a threat to terminate the venture is credible, as the VC loses nothing if he terminates the venture (to the contrary, he might make a profit). In contrast, when $e^{**}\Delta < I - A$, the VC must be promised a positive payoff prior to providing refinancing. The VC would therefore not terminate the venture if the entrepreneur deviated slightly from the equilibrium effort level.

There is thus a non–empty interval $\Sigma = [\underline{\Delta}, \bar{\Delta}) \subset \mathbb{R}_+^*$, such that for any $\Delta \in \Sigma$ the jointly efficient effort level strictly exceeds the equilibrium effort level under independent venturing *and* a threat to terminate the venture is credible. Next, define Δ_p by

$$e^{**}(\Pi - \Delta_p) - I - K - \psi(e^{**}) \equiv 0 \tag{15}$$

For $\Delta \leq \Delta_p$, it is efficient for the VC and the entrepreneur to launch the venture, provided the entrepreneur sticks to the effort level under independent venturing. In order not to inflate the number of cases to be considered, we will assume that $\Delta_p \geq \underline{\Delta}$ (formally, this amounts to $e^{**}\Pi - I - K - \psi(e^{**}) \geq I - A$). Hence, for $\Delta < \underline{\Delta}$, launching the venture is efficient if the entrepreneur sticks to e^{**}. It is then easily verified that $\Delta_p \geq \underline{\Delta}$ implies $\Delta^* > \underline{\Delta}$. Thus, for some $\Delta \in \Sigma$ (if not all) it is efficient to launch the venture if the entrepreneur sticks to the first best effort level.

We are now ready to state the paper's main results. The following proposition characterizes the equilibrium effort level for the case of a small strategic substitutability between the venture and the VC's portfolio firm.

Proposition 2 *Suppose the strategic substitutability between the entrepreneur's venture and the VC's portfolio firm is small, $\Delta < \underline{\Delta}$. Then, no matter whether the entrepreneur is financed by an independent VC or by the strategic VC, the entrepreneur expends the effort level under arm's length financing e^{**}. Consequently, the negative externality imposed on the strategic VC has no effect on the entrepreneur's performance.* ■

When the strategic substitutability between the two ventures is small, then there is neither a reason to induce the entrepreneur to compete less aggressively nor a means to make her work harder. This is because the jointly efficient effort level is still above the distorted effort level under independent venturing, but termination threats are not yet effective.

Next, consider the intermediate range of substitutabilities, $\Delta \in [\underline{\Delta}, \bar{\Delta})$. The following proposition demonstrates that the entrepreneur is ventured by the strategic

VC and expends the first best effort level. In particular, the entrepreneur competes *more* aggressively than under independent venturing.

Proposition 3 *Suppose* $\Delta \in [\underline{\Delta}, \bar{\Delta})$ *and* $\Delta \leq \Delta^*$. *Then,*

- *(financing) the entrepreneur is financed by the strategic VC. The VC commits to an initial cash transfer* $T = e^{**}\Delta \geq I - A$ *and holds the right to either*

  (i) close the refinancing gap by providing funds $K - [T - (I - A)] > 0$ *and obtain a share*

  $$\alpha = \frac{I - A + K + (e^{FB}(\Delta) - e^{**})\Delta}{e^{FB}(\Delta)\Pi} \tag{16}$$

  of the venture's product market income, or to

  (ii) terminate the venture and receive nothing.

  The entrepreneur commits to contribute her cash balance $T - (I - A)$ *to refinancing her venture, conditional on the VC closing the refinancing gap.*

- *(performance) the entrepreneur expends the first best effort level* $e^{FB}(\Delta)$. *In particular, the entrepreneur competes more aggressively than under independent venturing,* $e^{FB}(\Delta) > e^{**}$. ■

When the strategic substitutability between the two competing ventures is smaller than some threshold, the jointly efficient performance for the strategic VC and the entrepreneur is strictly superior to the equilibrium performance under independent venturing. An optimal financial contract thus induces the entrepreneur to expend *at least* the effort level under independent venturing. The proposition demonstrates that if the strategic substitutability is not too small either, then the contracting parties can achieve an even better performance. This is accomplished by designing the financial contract in such a way that the VC is incentivized to withhold refinancing if and only if the entrepreneur shirks, i.e. deviates from the first best effort level. The VC must have neither too *soft* nor *excessive* incentives to terminate the venture. Equipping the VC with the option to effectively terminate the venture addresses the first concern, while reducing the VC's *incremental* contribution to refinancing the venture addresses the second. In particular, if the VC closes the refinancing gap, he can call the entrepreneur's cash balance as to effectively reduce his contribution. This makes the VC willing to refinance the venture, rather than opportunistically terminating the venture in order to protect the previously funded portfolio firm.

The optimal financial contract has debt and equity features. Conditional on providing refinancing, the VC obtains a share α of the venture's *product market income*. In addition, the VC has a fixed claim on the venture's cash balance. The former element can be viewed as equity, the latter as debt. More important for the purpose of this paper are the competitive effects of the strategic substitutability between the two ventures on the entrepreneur's performance: Relative to independent VC

financing, the entrepreneur competes *more aggressively* when financed by the strategic VC. In other words, the competitive stance of the strategic VC's portfolio firm would have been less eroded if the VC rejected to finance the venture. The strategic VC thus willingly *cannibalizes* his previously funded portfolio firm. He is willing to do so because in equilibrium he is fully compensated for having the competitive stance of his portfolio firm eroded. If the VC had ex ante bargaining power over the entrepreneur, he would even capture part (or all) of the surplus gain from financing the entrepreneur, i.e. make a profit. Intuitively, the stake in the previously funded portfolio firm equips the strategic VC with a *competitive advantage* to incentivize the entrepreneur to perform better, i.e. to compete more aggressively. Furthermore, it may very well be that by establishing a financing relationship with the entrepreneur, the strategic VC is able to improve the performance of the previously funded portfolio firm (even though the entrepreneur competes more aggressively relative to independent venture backing). The same intuition that explains why the entrepreneur competes more aggressively would also allow to explain why the portfolio firm shows better performance.[19]

Next, suppose the strategic substitutability between the two ventures is larger than $\bar{\Delta}$ but not sufficiently large as to justify not launching the entrepreneur's venture. Then, we have the following

Proposition 4 *Suppose* $\bar{\Delta} \leq \Delta \leq \Delta^*$. *Then,*

- *(financing) the entrepreneur is financed by the strategic VC. The VC commits to an initial cash transfer* $T = e^{**}\Delta \geq I - A + K$ *in exchange for a share* $\alpha = \Delta/\Pi$ *of the venture's product market income. The VC does not hold any termination rights. The entrepreneur refinances her venture out of her cash balance* $T - (I - A)$.

- *(performance) the entrepreneur expends the first best effort level* $e^{FB}(\Delta)$. *For* $\Delta > \bar{\Delta}$, *the entrepreneur is softer than under independent venturing,* $e^{FB}(\Delta) < e^{**}$. ■

While launching the venture is still jointly efficient for the strategic VC and the entrepreneur, it is no longer efficient to incentivize the entrepreneur to compete more aggressively than under independent venturing. The strategic substitutability between the two competing ventures is too strong. It is thus optimal to soften

[19] Standard industrial organization models suggest that two competitors wish to jointly commit to softening their product market actions, at the expense of their customers (see e.g. Tirole 1990). Moreover, as long as product market actions are strategic complements, a firm will become more aggressive if the competitor becomes more aggressive too. These considerations may be *irrelevant* as soon as the competitors' actions are distorted due to the presence of agency problems. In particular, one firm becoming more aggressive may have no impact on the competitor's actions as long as those actions are sufficiently distorted. Similarly, the two competitors may very well wish to commit to be more "aggressive" (i.e. to perform better) — to their *joint* benefit (and to the benefit of their customers). Our analysis suggests that the strategic VC may play exactly the role of incentivizing the two competitors to be more aggressive, rather than inducing them to be softer.

the entrepreneur's performance incentives. This is accomplished by equipping the strategic VC with a soft equity–like claim in order to dilute the entrepreneur's claim. Crucially, financing the competing venture effectively enables the strategic VC to *control* the entrepreneur's product market actions and to align her incentives with his own interests.

The next proposition shows that when the strategic substitutability becomes very large, the entrepreneur's venture will no longer be launched.

Proposition 5 *Suppose* $\Delta > \Delta^*$. *Then, the entrepreneur is bought out by the strategic VC against a cash transfer* $T = e^{**}\Delta$ *and her product market idea is shelved.* ■

When the strategic substitutability becomes very large, it is no longer efficient to invest in the first place. Hence, the venture is bought out by the strategic VC. Doing so enables the strategic VC to prevent the entrepreneur from competing.[20] Note that rich entrepreneurs (those with large internal funds) receive a particularly high transfer payment in a buy out. This is because they have a credible threat to compete aggressively under independent VC financing. Poor entrepreneurs are softer under independent VC financing, hence, they receive less in a buy out.[21] Figure 2 summarizes the entrepreneur's performance (bold line) as a function of the strength of the strategic substitutability between the venture and the VC's portfolio firm:

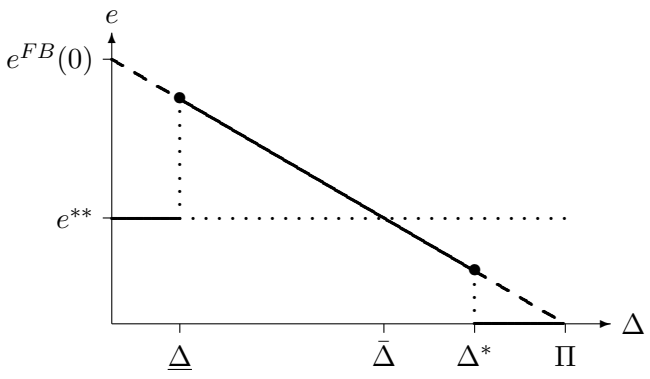

Figure 2: Performance

[20]Naturally, this rests on the assumption that non–competing clauses are enforceable. If non–compete clauses could not be enforced in court, the qualitative results would continue to hold true as long as the strategic VC can prevent the entrepreneur from competing by financing her venture, committing the entrepreneur to her firm, and irreversibly liquidating her venture at a later stage.

[21]See Cestone and White (2002) for a model where a firm's financier may take an equity stake in order to commit to *deny* funding to future competitors. For Δ sufficiently large, this consideration would be equally relevant in our setting if the entrepreneur did not have a credible threat to source funding elsewhere.

For $\Delta < \underline{\Delta}$, the negative externality imposed on the strategic VC's investment portfolio has no effect on the venture's performance relative to independent venturing. At $\Delta = \underline{\Delta}$, the VC can impose a credible termination threat as a result of which the effort level jumps to the first best. Performance is then gradually decreasing, as the entrepreneur internalizes the negative externality imposed on the VC's investment portfolio. At $\Delta = \bar{\Delta}$, we are back to the distorted arm's length effort level. Performance is further decreasing, until it no longer pays to launch the venture.

Figure 2 also illustrates the basic intuition behind our results. For $\Delta < \bar{\Delta}$, the jointly efficient effort level for the VC and the entrepreneur exceeds the equilibrium effort level under independent venture backing. Consequently, the joint objective of the VC and the entrepreneur is to find a mechanism that induces the entrepreneur to work harder than under independent VC financing. A novelty of this paper is to show that the VC will use his stronger commitment to terminate refinancing in order to incentivize the entrepreneur. For $\Delta > \bar{\Delta}$, the joint objective is no longer to incentivize the entrepreneur to work harder. Rather, the issue is how to prevent the entrepreneur from working too hard (in particular, the entrepreneur should work less than under independent VC financing). The VC holding equity allows to accomplish this goal. Equity dilutes the entrepreneur's claim and thus softens her performance incentives.

We will close this section by providing a brief discussion how to enrich our framework to account for *weak property rights*. A number of recent papers (Anand and Galetovic 2000, Anton and Yao 1994, 1995, Ueda 2000) studied the consequences of weak property rights in situations where either the financier may "steal" an entrepreneur's idea (Anton/Yao, Ueda) or an entrepreneur/researcher may ex post breakaway from a financier and launch her project elsewhere (Anand/Galetovic).[22] In our context, the first issue might have some relevance, namely, the strategic VC could have incentives to "steal" the entrepreneur's product idea when screening her project in order to prevent the entrepreneur from competing against his portfolio firm. We will provide a brief extension along those lines.

To fix ideas, consider the following (arguably simplistic) framework. From an ex ante perspective, the entrepreneur does not know whether the strategic VC is able to deploy her product idea (e.g. at the portfolio firm) or whether the VC is willing to incur the loss of reputation when stealing her idea. Formally, suppose that with probability ρ the VC will steal the entrepreneur's product idea, while with probability $1-\rho$ the VC is either not able or not willing to do so. Suppose too that the VC insists on screening the entrepreneur's project prior to providing funding (otherwise the VC would attract lots of entrepreneurs with worthless projects). While having her project screened, the entrepreneur reveals her product idea to the VC. Also, the VC reveals its type to the entrepreneur (the VC has no reason to hide his intentions). Next, if the VC deployed the idea, he would completely undermine the entrepreneur's prospects to ever reap positive profits. Finally, suppose that an

[22] Bhattacharya and Ritter (1983), Bhattacharya and Chiesa (1995), and Yosha (1995) address related issues.

independent investor has no interest in stealing the entrepreneur's product idea.[23]

Hence, if the entrepreneur approached the strategic VC, asked for funding, and had her project screened, then with probability ρ launching the project would no longer be worthwhile for the entrepreneur. A threat to seek funding elsewhere and compete against the VC's portfolio firm would no longer be credible. The entrepreneur would thus end up with her internal funds A. With probability $1-\rho$, however, the VC would not steal the entrepreneur's idea. Hence, the venture would either be launched or be bought out by the VC. The entrepreneur's expected payoff when approaching the VC thus amounts to

$$A + (1-\rho)(e^{**}\Pi - I - K - \psi(e^{**})) \tag{17}$$

for $\Delta < \underline{\Delta}$ and

$$A + (1-\rho)\left(e^{**}\Delta + \max\left[e^{FB}(\Delta)(\Pi-\Delta) - I - K - \psi(e^{FB}(\Delta)), 0\right]\right) \tag{18}$$

for $\Delta \geq \underline{\Delta}$. When approaching an independent VC, the entrepreneur's payoff is in turn given by

$$A + e^{**}\Pi - I - K - \psi(e^{**}) \tag{19}$$

Note that (19) strictly exceeds (17), while (18) exceeds (19) for ρ sufficiently small. We thus have the following

Proposition 6 *Suppose the entrepreneur faces the risk of being expropriated by the strategic VC, $\rho > 0$. Then,*

- *for $\Delta < \underline{\Delta}$, the entrepreneur will be financed by an independent VC*
- *for $\Delta \geq \underline{\Delta}$, the entrepreneur will be financed by the strategic VC if and only if the risk of expropriation is sufficiently small, $\rho \leq \rho^*$, where $\rho^* \in (0,1)$.* ■

When the entrepreneur faces the risk that the strategic VC may steal her product idea, she will have to trade off the benefits of being financed by the strategic VC with the risk of losing her product idea.[24] One would expect expropriation risk (ρ) to be negatively correlated with the financier's *reputation* but to be positively correlated with the extent of the *competitive threat* the venture imposes on the financier's portfolio firm. This suggests that expropriation risk should be of little concern for the entrepreneur as long as she is backed by an experienced and established financier (and the competitive threat imposed on the financier's portfolio firm is not too severe).[25] The next section provides an examination of the investment activities of Kleiner & Perkins, a distinguished and reputable venture capital firm, in light of the analysis.

[23] All what matters is that the strategic VC has a *stronger* interest to steal the entrepreneur's product idea than an independent investor.

[24] As discussed in the introduction, Hellmann (2002) suggests another potential cost of being funded by the strategic VC. He shows that strategic substitutabilities may undermine the VC's incentives to provide the venture with support. This suggests that the entrepreneur might have to trade off the potential lack of support with her superior commitment to perform if backed by the strategic VC.

[25] See Hellmann (1997) for an insightful discussion about the risk of expropriation in venturing financing.

5 Kleiner & Perkins: Keiretsu vs Cannibalization

Since its foundation in 1972, Kleiner & Perkins (short for Kleiner, Perkins, Caufield & Byers) has invested in hundreds of companies "that have resulted in the creation of over 250,000 new jobs, over $100 billion in new revenue, and over $650 billion in market capitalization".[26] Among those companies are household names, such as Amazon.com, AOL, Compaq, Sun Microsystems, Genentech, Juniper Networks, and Netscape. Kleiner & Perkins is known for its *keiretsu* approach to venture investing. This is best illustrated with the following quote, taken from Kleiner & Perkins' website:

> *"One of the best ways to launch a new venture and grow it into a successful enterprise is through forming partnerships. To help expedite relationships, we put together an informal network of our portfolio companies. [...] The Keiretsu gives emerging start up companies a unique ability to learn from more established operations, entrepreneurs an opportunity to pool their experiences, and companies an environment to explore synergies."*

Kleiner & Perkins indeed backed many companies that *complement* each other. Consider, for example, some of Kleiner & Perkins' investments along the networking supply chain (table 1). Kleiner & Perkins backed a number of exchange carriers, such as XO Communications, Zephion Networks, Broadband Office, 360networks, and OnFiber Communications.[27] These companies are potential customers of networking equipment makers. Within this segment, Kleiner & Perkins financed numerous companies, for example Corvis, Lightera (acquired by Ciena), Siara (acquired by Redback), ONI Systems, Zaffire (acquired by Centerpoint), and Juniper Networks. These companies in turn source from component makers, e.g. those backed by Kleiner & Perkins, namely Kymata (acquired by Alcatel), Iolon, and Cenix.

It is easy to see how such a supply chain network with a VC partner assuming a *coordinating* role between upstream and downstream firms can help to create value. For example, by funding and assisting downstream firms a VC partner may acquire expertise about their needs and requirements. Channeling this knowledge to upstream firms should help these firms to develop their businesses. Conversely, through dealing with upstream firms, the VC partner may get a precise idea what these firms can deliver. This in turn should facilitate decision making at the downstream end of the market. The VC partner may also play a decisive role in bringing customers and suppliers together in the first place.[28] Furthermore, having a stake in an *upstream* firm can help to commit the VC partner to provide a *downstream*

[26] See Kleiner & Perkins' website at http://www.kpcb.com.

[27] By the end of 2001, Zephion Networks and Broadband Office closed down and 360networks filed for bankruptcy. XO Communications had its stock voluntarily delisted from the Nasdaq exchange after announcing that two strategic investors would supply the company with fresh money in exchange for control and new equity. OnFiber is held privately.

[28] See Lightreading, April 05, 2000, and June 01, 2001, for anecdotes of how Kleiner & Perkins tried to influence Kleiner & Perkins backed carriers to purchase equipment from Kleiner & Perkins

market segment	KP companies
component makers	Kymata (Alcatel), Iolon, Cenix
equipment makers	Lightera (Ciena), Corvis, ONI Systems, Zaffire (Centerpoint) Siara (Redback), Juniper Networks
exchange carriers	XO Communications, Zephion Networks, BroadBand Office, 360networks, OnFiber Communications

Table 1: Kleiner & Perkins' networking supply chain

firm with support and advice, because ultimately the latter could be a customer of the former.[29]

A closer look at Kleiner & Perkins' networking *keiretsu* reveals, however, that within segments of the networking supply chain, Kleiner & Perkins backed ventures that were actual or potential competitors. In what follows, we will illustrate such practice with some of Kleiner & Perkins' investments in the networking equipment space (table 2). These examples have in common that Kleiner & Perkins invested in a venture at a time where it still had a significant stake in another, previously launched venture. Moreover, the two ventures were actual or potential competitors. This corresponds exactly to the pattern proposed in our formal framework.

KP company	first inv.	status	KP stake
Lightera	na	acq. by Ciena (03/99)	na
Corvis	05/98	IPO 07/00	10% (04/01)
ONI Systems	01/98	IPO 06/00	9% (04/01)
Zaffire	08/00	acq. by Centerpoint (10/01)	na
CoSine	03/99	IPO 09/00	7% (09/00)
Smartpipes	03/00	private	na
Cerent	04/97	acq. by Cisco (08/99)	30% (08/99)
Siara	na	acq. by Redback (03/00)	na
Zepton Networks	03/01	private	na

Table 2: Networking equipment portfolio

companies. Vinod Khosla, a partner at Kleiner & Perkins, also has a board seat at Qwest Communications, a carrier not backed by Kleiner & Perkins, but a customer of e.g. Corvis and Juniper Networks.

[29]See Hellmann (2002) for a model along those lines. Hellmann and Puri (2000, 2002) provide empirical evidence about the role of VCs in supporting firms to shape their product market strategies and to develop their ventures.

Ciena and Corvis are makers of optical networking equipment for telecommunication carriers.[30] Ciena became a leader in the market for optical switches through its March 1999 acquisition of Lightera, a Kleiner & Perkins' backed venture. Its flagship product, the CoreDirector, is a so–called optical–electrical–optical ("OEO") switch in that it relies on electrical regeneration of light signals.[31] In May 1998, i.e. almost one year before Ciena's acquisition of the CoreDirector, Kleiner & Perkin's made its first investment in Corvis. The value proposition of Corvis stems from an all–optical concept. In particular, Corvis' flagship optical switch does not rely on electrical regeneration of light signals, but instead has an optical core. All–optical switching is widely regarded to be more cost effective than OEO switching, suggesting that Corvis could severely undermine Ciena's competitive stance. However, there are certain technical bottlenecks associated with all–optical switches, as a result of which carriers typically deploy the two products in different parts of their networks.[32] This suggests that the two products are best viewed as *imperfect* substitutes. By the end of 2001, Corvis complemented its product portfolio with an OEO switch. This puts Corvis into "direct" competition with Lightera/Ciena.

ONI Systems and Zaffire (acquired by Centerpoint in October 2001) produce next–generation optical networking gear for metropolitan networks. Kleiner & Perkins made its first investment in ONI Systems in January 1998, the company went public in June 2000. Two months later, in August 2000, Kleiner & Perkins made its first investment in Zaffire, while still holding a significant equity stake in ONI Systems (in April 2001, it had a 9% stake).[33] While ONI Systems' and Zaffire's respective product offerings display some degree of differentiation, the two companies are widely regarded to be competitors.[34]

CoSine Communications and Smartpipes are makers of virtual private networking hard– and software. The first investment in CoSine was made in March 1999, CoSine went public in September 2000 (at that time, Kleiner & Perkins held a 7% stake in CoSine).[35] Six months before the IPO, in March 2000, Kleiner & Perkins made its first investment in Smartpipes. CoSine and Smartpipes are deemed to be potential competitors (Red Herring, May 2001).

Siara and Cerent emerged from the break up of another company, Fiberlane Communications, after an internal fight between two camps of engineers.[36] Kleiner & Perkins financed Fiberlane and continued to fund both Siara and Cerent as stand–

[30]Interestingly, both have the same founder, David Huber, who is now CEO of Corvis.

[31]See Lightreading at http://www.lightreading.com for a collection of white papers explaining the technical aspects of optical networking gear.

[32]Importantly, however, carriers can rely on either OEO or OOO switches. This implies that Lightera/Ciena's pricing power is constrained by Corvis' pricing (et vice versa). See footnote 9 for further discussion of when two companies compete and when not.

[33]See ONI System's April 2001 proxy filing.

[34]See various reports at Lightreading.

[35]See Cosine's S–1 filing, September 2000.

[36]See Red Herring, September 1999, and The Press Democrat, December 12, 1999.

alone units.[37] In August 1999, Cerent was acquired by Cisco Systems (for a record amount), while Siara was acquired by Redback Networks in March 2000. Both Cerent and Siara provided telecommunication carriers with optical networking gear to enhance the efficiency of their first–generation SONET optical networks. The available evidence suggests that while their products were initially meant to address different needs, the companies eventually broadened their product portfolios and re–entered each others turf.[38]

In March 2001, Kleiner & Perkins invested in Zepton Networks, a start–up company devoted to optical networking gear. The company is mute on what kind of products it will eventually deliver. Company sources suggest, however, that its technology could be quite drastic. To quote founder David Welch, "we are drawing on systems– and component–level expertise to deliver a product that will revolutionize optical networking." (Light Reading, June 26, 2001). In April 2001, Kleiner & Perkins held a 10% stake in optical networking equipment maker Corvis and a 9% stake in metro optical systems maker ONI Systems.

These examples reveal a common pattern: Kleiner & Perkins invested in a competing venture at a time where it still had a sizable (but not excessively large) stake in a portfolio firm. Moreover, the ventures' respective product offerings often displayed some degree of differentiation. This suggests that in practice the intermediate range of strategic substitutabilities considered in the previous section is indeed most relevant. In many cases, even long after a portfolio firm's IPO and the expiry of lock–up provisions, did Kleiner & Perkins continue to be invested in a portfolio firm.[39] This is consistent with more systematic empirical evidence indicating that venture capital organizations often retain substantial holdings in their portfolio firms, even long after a portfolio firm's IPO (Barry et al. 1990, Gompers and Lerner 1999, Megginson and Weiss 1991). It is also consistent with our theory that a VC may want to retain a stake in a portfolio firm in order gain a competitive advantage in financing an actual or a potential competitor of that portfolio firm.[40]

The case study also provides support for our main prediction that a stake in a portfolio firm enhances a VC's ability to strengthen entrepreneurial performance incentives. In particular, Kleiner & Perkins does not seem to have played a role in softening competition. To the contrary, some of its portfolio firms became fierce competitors. The Lightera/Corvis example is particularly revealing in that Ciena launched a series of lawsuits against Corvis, alleging the latter to engage in unfair

[37] A third company emerging from the Fiberlane breakup, Cyras, received funding from another VC firm. In March 2001, Cyras was acquired by Ciena.

[38] See various reports at Lightreading.

[39] See e.g. ONI Systems and Corvis. Other examples include Brio Technology (IPO in May 1998, 6% stake in July 2000), E.piphany (IPO in September 1999, 12% stake in April 2000, 4% stake in April 2001), and Juniper Networks (IPO in June 1999, 19% stake in April 2000, 8% stake in April 2001). See the companies' respective proxy filings.

[40] Note that our framework does not address why venture capitalists divest stakes in the first place (for example, in an IPO). This would be beyond the scope of the present paper. See Aghion et al. (2000) for a recent model on exit options in corporate finance.

competition.[41] Conversely, Corvis faces price pressures from Ciena.[42] At the same time, both Corvis and Ciena are relatively successful players in their respective market segments. Ciena became a market leader in the market for OEO switches through its acquisition of Lightera; Corvis is a first mover and leader in the market for all–optical OOO switches.

6 Discussion and Conclusions

This paper demonstrates how strategic substitutabilities between a VC's portfolio firms affect entrepreneurial incentives and venture performance. The analysis suggests that, in some cases, a VC may want to finance a competing venture in order to prevent an entrepreneur from seeking finance elsewhere and to soften her aggressiveness. If the VC did not finance the venture, the entrepreneur would seek financing elsewhere and compete aggressively, eventually. Financing the venture enables the VC to control the entrepreneur and to align her incentives with his own interests. In many other cases, however, the VC will rationally back the venture even though the entrepreneur would have been *less* aggressive if financed by an independent VC. In other words, the VC willingly *cannibalizes* his own portfolio firm. This is because the stake in the portfolio firm conveys the VC with a competitive advantage in financing an actual or potential competitor of the portfolio firm, stemming from his superior commitment to cut down refinancing. The stake in the portfolio firm thus serves as a substitute for collateral.[43] In contrast, under independent VC financing, a threat to cut down refinancing lacks credibility as an independent VC has too much to lose and too little to gain from terminating the venture.

Results depend critically on the strength of the strategic substitutability between the two ventures. When the negative externality imposed on the portfolio firm is very small, then neither is there a reason to soften the entrepreneur's actions, nor is there a means to make her work harder. This is because the *jointly* efficient effort level is still above the distorted effort level under independent VC financing, but termination threats are not yet effective. If the negative externality imposed on the VC's portfolio firm is neither too small nor too large, then the entrepreneur will compete more aggressively than under independent VC financing. Conversely, if the strategic substitutability becomes very large, the entrepreneur's product market actions will be softened.

The analysis points to a number of novel insights: (i) financing a venture that would compete against a previously launched portfolio firm can be *value–enhancing*; (ii) relative to independent VC financing, the venture may perform *more* aggressively if backed by the strategic VC as the stake in the previously launched competitor

[41] See the companies' respective 2000 10–K reports.

[42] See Merrill Lynch research report April 27, 2001.

[43] See, among others, Berglöf and von Thadden (1994), Bolton and Scharfstein (1996), Dewatripont and Tirole (1994), Hart and Moore (1998), and Repullo and Suarez (1998) for discussions how collateral, security design, and multiple source financing allow to strengthen the credibility of termination threats.

enhances the VC's ability to incentivize the venture; (iii) the VC may want to *retain* a stake in a portfolio firm even after the firm's IPO in order to enhance his *competitive advantage* in financing a venture that operates in the same space, addresses similar needs, and may even become a competitor of the portfolio firm.

We confronted the analysis with a case study of the investment activities of US venture capital firm Kleiner & Perkins in the networking equipment space. The case study suggests that Kleiner & Perkins backed a competing venture at a time when it had a substantial but not excessively large stake in a previously funded portfolio firm the venture would compete against. This pattern is consistent with the model's implications. The case study further suggests that Kleiner & Perkins frequently retained substantial holdings in a portfolio firm after the firm's IPO. This is consistent with empirical evidence indicating that VC organizations tend to continue to be invested in their portfolio firms (rather than completely divesting their stakes), even after the expiry of lock–up provisions. We provide a novel explanation for this pattern. Finally, the case study suggests that Kleiner & Perkins does not seem to have played a role in softening its portfolio firms' performance and hence their aggressiveness. To the contrary, some of its portfolio firms became fierce competitors.

We were mute about the portfolio firm's actions. There are two interesting issues: (i) wouldn't the portfolio firm have incentives to buy out the competing venture? (ii) how are the portfolio firm's product market actions affected? As for the first issue, one should note that the ability of the portfolio firm to buy out the competing venture is not only hampered by its own financial resources but also by antitrust restrictions. As for the second issue, even the portfolio firm may very well be incentivized to act more aggressively. This is because the same logic that explains why a stake in the portfolio firm enables the VC to discipline the competing venture would also explain why a stake in the competing venture allows the VC to discipline the portfolio firm.[44]

There is a complementary explanation for why VCs fund actual or potential competitors of existing portfolio firms: Economies of scale. Indeed, VCs often fund ventures that promise to deliver highly complex products in emerging markets. Assisting and coaching these ventures requires technical expertise, industry contacts, and other assets which are costly to acquire. It is therefore natural that VCs capitalize on previously acquired expertise and fund ventures that operate in the same space, address similar needs, and may even become competitors. Introducing such economies of scale into our framework model would strengthen the strategic VC's incentives to back a competing venture. However, a theory which were based on economies of scale alone would not allow to explain why VCs retain substantial holdings in their portfolio firms after an IPO or the expiry of lock–up periods.

This paper aims at making a contribution towards a deeper understanding of how the *composition* of a VC's investment portfolio and the *nature of the strategic interaction* between a VC's portfolio firms affect performance in venture capital

[44]See also the discussion in section 4 and footnote 19.

financing.[45] While this paper focused on the case of competing ventures, VC organizations and corporations often finance ventures that complement their existing investment portfolios or product lines (as is illustrated by Kleiner & Perkins' "networking supply chain" discussed in section 5). Hellmann (2002) points to the bright side of such complementarities. He suggests that complementarities can help to commit a VC to coach a venture. We argue elsewhere that if a venture that brought strong positive synergies to an investor's existing portfolio firms (or product lines) could be financed elsewhere, then the investor might not want to finance the venture himself (Arping 2002). This is because, ultimately, the investor might be too hesitant to respond to poor performance with termination as he would lose the strategic benefits the venture conveys to his existing product lines. As a result, the venture would have relatively poor incentives to perform. This suggests that a smart VC would spice up a portfolio of synergistic firms with ventures that are actual or potential competitors of these firms. Such a strategy restores the VC's incentives to cut down poorly performing ventures, if needed, and thus improves overall performance. This seems to be in line with Kleiner & Perkins' investment strategy.

References

Aghion, P., Bolton, P., and J. Tirole, 2000, "Exit Options in Corporate Finance: Liquidity versus Incentives," Mimeo, IDEI Toulouse.

Anand, B. and A. Galetovic, 2000, "Weak Property Rights and Holdup in R&D," *Journal of Economics and Management Strategy* 9, 615–642.

Anton, J. and D. Yao, 1994, "Expropriation and Inventions: Appropriable Rents in the Absence of Property Rights," *American Economic Review* 84, 777–795.

Anton, J. and D. Yao, 1995, "Start–Ups, Spin–Offs, and Internal Projects," *Journal of Law, Economics and Organization* 11, 362–378.

Arping, S., 2001, "Banking, Commerce, and Antitrust," Mimeo, University of Lausanne.

Arping, S., 2002, "The Perils of Corporate Venturing," Mimeo, University of Lausanne.

Barry, C., Muscarrela, C., Peavy, J. and M. Vetsuypens, 1990, "The Role of Venture Capital in the Creation of Public Companies: Evidence from the Going–Public Process," *Journal of Financial Economics* 27, 447–471.

Berglöf, E. and E. von Thadden, 1994, "Short-Term versus Long-Term Interests: Capital Structure with Multiple Investors," *Quarterly Journal of Economics* 109, 1055–1084.

Bhattacharya, S. and J. Ritter, 1983, "Innovation and Communication: Signaling with Partial Disclosure," *Review of Economic Studies* 50, 331–346.

[45] See Kanniainen and Keuschnigg (2001) for an analysis of the optimal *number* of start–up firms in a VC's portfolio.

Bhattacharya, S. and G. Chiesa, 1995, "Proprietary Information, Financial Intermediation, and Research Incentives," *Journal of Financial Intermediation* 4, 328–357.

Bolton, P. and D. Scharfstein, 1996, "Optimal Debt Structure and the Number of Creditors," *Journal of Political Economy* 104, 1–25.

Cestone, G. and L. White, 2002, "Anti–Competitive Financial Contracting: The Design of Financial Claims," CEPR Working Paper No. 3182.

Dewatripont, M. and J. Tirole, 1994, "A Theory of Debt and Equity: Diversity of Securties and Manager–Shareholder Congruence," *Quarterly Journal of Economics* 109, 1027–1054.

Gompers, P., 1995, "Optimal Investment, Monitoring, and the Staging of Venture Capital," *Journal of Finance* 50, 1461–1489.

Gompers, P. and J. Lerner, 1999, "An Analysis of Compensation in the U.S. Venture Capital Partnership," *Journal of Financial Economics* 51, 3–44.

Gorman, P. and W. Sahlman, 1989, "What Do Venture Capitalists Do?" *Journal of Business Venturing* 4, 231–248.

Grossman, G. and C. Shapiro, 1986, "Research Joint Ventures: An Antitrust Analysis," *Journal of Law, Economics, and Organization* 2, 315–337.

Hart, O. and J. Moore, 1998, "Debt, Default and Renegotiation," *Quarterly Journal of Economics* 113, 1–41.

Hellmann, T. 1997, "Some Thoughts on the Theory of Corporate Venture Investing," Mimeo, Stanford University.

Hellmann, T., 2002, "A Theory of Strategic Venture Investing," *Journal of Financial Economics*, forthcoming.

Hellmann, T. and M. Puri, 2000, "The Interaction Between Product Market and Financing Strategy: The Role of Venture Capital," *Review of Financial Studies* 13, 959–984.

Hellmann, T. and M. Puri, 2002, "Venture Capital and the Professionalization of Start–Up Firms: Empirical Evidence," *Journal of Finance* 57, 169–197.

Kanniainen, V. and C. Keuschnigg, 2001, "The Optimal Portfolio of Start–up firms in Venture Capital Finance," Mimeo, University of St. Gallen.

Kaplan, S. and P. Strömberg, 2000, "Financial Contracting Meets the Real World: An Empirical Analysis of Venture Capital Contracts," Mimeo, Graduate School of Business, University of Chicago.

Leshchinskii, D., 2000, "Venture Capitalists as Benevolent Vultures: The Role of Network Externalities in Financing Choice," Mimeo, HEC Paris.

Lerner, J., 1995, "Venture Capitalists and the Oversight of Private Firms," *Journal of Finance* 50, 301–318.

Megginson, W. and K. Weiss, 1991, "Venture Capital Certification in Initial Public Offerings," *Journal of Finance* 46, 879–903.

Ordover, J. and R. Willig, 1985, "Antitrust of High–Technology Industries: Assessing Research Joint Ventures and Mergers," *Journal of Law and Economics* 72, 311–333.

Porter, M., 1985, *Competitive Advantage: Creating and Sustaining Superior Performance,* Free Press, New York.

Rajan, R., 1992, "Insiders and Outsiders: The Choice Between Informed and Arm's Length Debt," *Journal of Finance* 47, 1367–1400.

Repullo, R. and J. Suarez, 1998, "Monitoring, Liquidation, and Security Design," *Review of Financial Studies* 11, 163–187.

Sahlman, W., 1990, "The Structure and Governance of Venture Capital Organizations," *Journal of Financial Economics* 27, 473–521.

Shapiro, C. and R. Willig, 1990, "On the Antitrust Treatment of Production Joint Ventures," *Journal of Economic Perspectives* 4, 113–130.

Tirole, J., 1990, *The Theory of Industrial Organization*, MIT Press, Cambridge.

Ueda, M., 2000, "Bank versus Venture Capital," Mimeo, Universitat Pompeu Fabra.

Yosha, O., 1995, "Information Disclosure Costs and the Choice of Financing Source," *Journal of Financial Intermediation* 4, 3–20.

Appendix

Proof of proposition 1: In order to complete the proof, we have to show that the first best and the equilibrium effort levels exist and are interior. Consider the first best effort level,

$$\Pi - \psi'(e^{FB}) = 0 \tag{20}$$

Since $\lim_{e\to 0}\psi'(e) = 0$, $\lim_{e\to 1}\psi'(e) \to \infty$, and $\psi'(e)$ is continuous and increasing in e, e^{FB} exists, is unique and interior.

Next, consider the binding incentive constraint under arm's length financing,

$$\varphi(e) = \left(1 - \frac{I - A + K}{e\Pi}\right)\Pi - \psi'(e) = 0 \tag{21}$$

Note that $\varphi(e)$ is continuous, strictly concave (from $\psi'''(e) \geq 0$), and satisfies $\lim_{e\to 0}\varphi(e) \to -\infty$ and $\lim_{e\to 1}\varphi(e) \to -\infty$. Suppose that a generic solution to $\varphi(e) = 0$ exists (by assumption, outside financing is feasible), i.e. $\max_e \varphi(e) > 0$. Hence, $\varphi(e) = 0$ will have exactly two interior solutions. Since $K - A + I > 0$ and $\psi'(e)$ is increasing, any such solution will be inferior to the first best effort level. Hence, the optimum is given by the largest solution. ■

Proof of lemma 1: See the discussion in the text. ■

Proof of lemma 2 and proposition 2: We will show that as long as the strategic VC breaks even in equilibrium, a threat to liquidate the venture after a small deviation from the equilibrium effort level cannot be credible for $I - A - e^{**}\Delta > 0$ (i.e. $\Delta < \underline{\Delta}$).

Suppose the entrepreneur expends effort e^* in equilibrium. Hence, for the VC to break even,

$$e^*(\alpha\Pi + V - \Delta) + (1 - e^*)V = V - e^{**}\Delta + I - A + K \tag{22}$$

where the right hand side is the VC's payoff under the outside option, $V - e^{**}\Delta$, plus the VC's total investment, $I - A + K$. Hence,

$$\alpha = \frac{I - A + K + (e^* - e^{**})\Delta}{e^*\Pi} \tag{23}$$

Suppose a threat to terminate the venture is credible for any $e < e^*$. Formally, for any $e < e^*$,

$$e(\alpha\Pi + V - \Delta) + (1 - e)V - K \leq V \tag{24}$$

By continuity,

$$e^*(\alpha\Pi + V - \Delta) + (1 - e^*)V - K \leq V \tag{25}$$

However,

$$e^*(\alpha\Pi + V - \Delta) + (1 - e^*)V - K = V - e^{**}\Delta + I - A > V \tag{26}$$

since $I - A - e^{**}\Delta > 0$. Hence, a termination threat cannot be credible.

The equilibrium effort level is therefore given by the largest solution of

$$\varphi(e) = \left(1 - \frac{I - A + K + (e - e^{**})\Delta}{e\Pi}\right)\Pi - \psi'(e) = 0 \tag{27}$$

Note that $e = e^{**}$ is a solution to $\varphi(e) = 0$. We will show that it is the optimal solution. Note that $\varphi(e)$ is continuous, strictly concave (from $\psi'''(e) \geq 0$), and satisfies $\lim_{e\to 0}\varphi(e) = \lim_{e\to 1}\varphi(e) \to -\infty$, since $I - A + K - e^{**}\Delta > 0$. Suppose that a generic solution to $\varphi(e) = 0$ exists, i.e. $\max_e \varphi(e) > 0$. Hence, $\varphi(e) = 0$ will have exactly two solutions. Since $I - A + K + (e - e^{**})\Delta > 0$ and $\psi'(e)$ is increasing, any such solution will be inferior to the first best effort level. Hence, the optimum is given by the largest solution and, moreover, coincides with the effort level under arm's length financing, e^{**}. ■

Proof of propositions 3 to 5: We will first show that if launching the venture is efficient ($\Delta \leq \Delta^*$), then the entrepreneur expends first best effort and the strategic VC breaks even, provided the parties employ the financial contracts as specified in propositions 3 and 4.

Case 1, $\Delta \in [\underline{\Delta}, \bar{\Delta})$ (proposition 3): Suppose the entrepreneur exerts effort e. Then, in order for the VC to be willing to close the refinancing gap

$$e(\alpha\Pi + V - \Delta) + (1 - e)V - (K - e^{**}\Delta + I - A) \geq V \tag{28}$$

where

$$\alpha = \frac{I - A + K + (e^{FB}(\Delta) - e^{**})\Delta}{e^{FB}(\Delta)\Pi} \tag{29}$$

Note that $\alpha\Pi > \Delta$, from $K > e^{**}\Delta - (I - A)$ (or $\Delta < \bar{\Delta}$). Hence, substituting (29), (28) reduces to

$$e \geq \frac{I - A + K - e^{**}\Delta}{\alpha\Pi - \Delta} = e^{FB}(\Delta) \tag{30}$$

Conversely, for $e < e^{FB}(\Delta)$, the VC is better off with terminating the venture. Since refinancing is ex post (strictly) efficient at e^{FB}, it must be ex post efficient also for some e slightly below e^{FB}. For such e, renegotiation is triggered, and the entrepreneur offers the VC a share $\alpha(e)$ such that the VC is willing to close the refinancing gap,

$$e(\alpha(e)\Pi + V - \Delta) + (1 - e)V - (K - e^{**}\Delta + I - A) = V \tag{31}$$

or

$$\alpha(e) = \frac{I - A + K + (e - e^{**})\Delta}{e\Pi} \tag{32}$$

Note that $\alpha(e)$ is strictly decreasing in e since $K > e^{**}\Delta - (I - A)$. The entrepreneur's payoff from slightly undercutting $e^{FB}(\Delta)$ thus amounts to

$$e(1 - \alpha(e))\Pi - \psi(e) = e(\Pi - \Delta) - I + A - K + e^{**}\Delta - \psi(e) \tag{33}$$

which is maximized at $e = e^{FB}(\Delta)$. Hence, around $e^{FB}(\Delta)$, the entrepreneur's payoff is maximized at $e^{FB}(\Delta)$, since

$$(1 - \alpha)\Pi = \Pi - \Delta - \frac{I - A + K - e^{**}\Delta}{e^{FB}(\Delta)} < \psi'(e^{FB}(\Delta)) \tag{34}$$

from $K > e^{**}\Delta - (I - A)$ and $\Pi - \Delta = \psi'(e^{FB}(\Delta))$. To verify that the entrepreneur is indeed better off making the VC an offer to close the refinancing gap if refinancing is efficient (rather than letting the VC terminate her venture in which case the entrepreneur would consume her internal funds), note that

$$e(1 - \alpha(e))\Pi = e(\Pi - \Delta) - K + e^{**}\Delta - I + A \geq e^{**}\Delta - I + A \tag{35}$$

if and only refinancing is efficient, $e(\Pi - \Delta) - K \geq 0$. Suppose the entrepreneur expends an effort level such that refinancing is inefficient, $e(\Pi + \Delta) - K < 0$. Hence, the entrepreneur lets the VC terminate her venture and consumes her internal funds $e^{**}\Delta - I + A$. If this were optimal for the entrepreneur, she would expend zero effort. The entrepreneur does not hold up the VC by exerting zero effort if and only if

$$e^{FB}(\Delta)(\Pi - \Delta) - I + A - K + e^{**}\Delta - \psi(e^{FB}(\Delta)) \geq e^{**}\Delta - I + A \tag{36}$$

which holds since launching the venture is efficient, $e^{FB}(\Delta)(\Pi - \Delta) - K - I - \psi(e^{FB}(\Delta)) \geq 0$. Finally, note that the VC just breaks even, since

$$e^{FB}(\Delta)(\alpha\Pi + V - \Delta) + (1 - e^{FB}(\Delta))V - I + A - K = V - e^{**}\Delta \tag{37}$$

Hence, the contract is optimal.

Case 2, $\Delta \in [\bar{\Delta}, \Delta^*)$ (proposition 4): Note that the entrepreneur's cash balance at $t = 2$ is sufficient as to self–refinance her venture, $e^{**}\Delta - (I - A) \geq K$. Suppose the entrepreneur exerts effort such that refinancing her venture is optimal for her. Her payoff function thus amounts to

$$e(\Pi - \Delta) + e^{**}\Delta - I + A - K - \psi(e) \tag{38}$$

which is maximized at $e^{FB}(\Delta)$. Alternatively, she could refrain from working, in which case she would be left with her internal funds $A - I + e^{**}\Delta$. Again, the entrepreneur has no interest to hold up the VC since launching the venture is efficient. Finally, note that the VC breaks even, since

$$e^{FB}(\Delta)(V - \Delta + \Delta) + (1 - e^{FB}(\Delta))V - e^{**}\Delta = V - e^{**}\Delta \tag{39}$$

Hence, the contract is optimal.

We conclude that if the venture is launched, then the entrepreneur expends first best effort, resulting in an ex ante payoff of

$$e^{FB}(\Delta)(\Pi - \Delta) - I + A - K + e^{**}\Delta - \psi(e^{FB}(\Delta)) \tag{40}$$

If launching the venture is not efficient then, obviously, the entrepreneur is bought out by the VC against a payment $T = e^{**}\Delta$, resulting in an ex ante payoff of $e^{**}\Delta + A$ (proposition 5).

We will now argue that the entrepreneur is better off being financed (or bought out) by the strategic VC than being financed by an independent investor. Suppose first that launching the venture is efficient. Then, the entrepreneur will be strictly better off with the VC if her payoff under venturing by the VC strictly exceeds her payoff under independent venturing,

$$e^{**}\Pi - I + A - K - \psi(e^{**}) \tag{41}$$

By inspection, (40) strictly exceeds (41) if

$$e^{FB}(\Delta)(\Pi - \Delta) - \psi(e^{FB}(\Delta)) > e^{**}(\Pi - \Delta) - \psi(e^{**}) \tag{42}$$

which, from concavity and $\Delta > 0$, holds by revealed preference. Next, if launching the venture is inefficient, the entrepreneur will be strictly better off with the VC if

$$A > e^{**}(\Pi - \Delta) - I + A - K - \psi(e^{**}) \tag{43}$$

which holds again since

$$e^{**}(\Pi - \Delta) - I - K - \psi(e^{**}) < e^{FB}(\Delta)(\Pi - \Delta) - I - K - \psi(e^{FB}(\Delta)) < 0 \tag{44}$$

by revealed preference. To conclude, for $\Delta \in [\underline{\Delta}, \Delta^*]$, the venture will be launched and the entrepreneur will expend first best effort. For $\Delta > \Delta^*$, the venture will be acquired by the VC. ■

Proof of proposition 6: See the discussion in the text. ■